

## The Effect of Gender on Dimensions of Lumbar Vertebral Pedicle Using Computed Tomography

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### ABSTRACT

**BACKGROUND AND OBJECTIVE:** Having the correct anatomical points and the size of the pedicle dimension is necessary to minimize neurological complications. Currently, the gold standard for spinal fusion is the use of pedicle screws. In this method, the pedicle screw should be placed in its ideal position. Given the importance of this topic, the present study was performed to determine the dimensions of right and left pedicle by computed tomography (CT) scan in three axial, coronal and sagittal planes based on gender in Fars-native ethnic group.

**METHODS:** This cross-sectional study was performed on 40 patients (20 females and 20 males aged 18 – 45 years) from Fars-native ethnic group. The average height for males was 165 to 180 cm and for females between 165 and 175 cm. Healthy vertebrae were selected in people who referred to a CT scan unit with symptoms of spinal pain or trauma. Determination of height, length and width of right and left pedicle of lumbar vertebrae in axial, coronal and sagittal view in 1.5 mm sections was performed by CT scan.

**FINDINGS:** Mean and standard deviation of height ( $1.458 \pm 0.141$ ), width ( $0.788 \pm 0.173$ ), and length ( $1.248 \pm 0.195$ ) of pedicle in men (based on millimeter) was significantly higher compared to mean and standard deviation of height ( $1.268 \pm 0.140$ ), width ( $0.618 \pm 0.148$ ), and length ( $1.08 \pm 0.174$ ) in women ( $p < 0.05$ ).

**CONCLUSION:** The results of this study showed that gender affects the dimensions of lumbar vertebral pedicle.

**KEY WORDS:** *Pedicle, Lumbar Vertebra, Ethnicity, Gender, CT scan.*

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## Introduction

Assessment and measurement of human body dimensions is performed using physical anthropometry. Morphometry is a branch of anthropometrics that measures the anatomical size of different dimensions of the human body, including the lumbar spine (1). Dry parts are also used in the anatomy section for lumbar vertebra morphometry (2).

Studies have shown that CT scan is the best method for pedicle morphometry of lumbar vertebrae (3, 4). Maaly et al. carried out a morphometric study in Egypt on both corpse and patients (5). In various studies, there was no difference in measurement between the use of CT scans and the use of corpse or directly measured dry lumbar vertebrae (6, 7).

The vertebral structure consists of the body in the anterior portion and the vertebral arch in the posterior portion. The vertebral arch consists of the pedicle and lamina. The vertebral arch is attached to the body by the pedicle and forms the vertebrae in which the spinal cord and nerves are located (8).

Morphometric information about pedicle and knowledge of the anatomical structure of the lumbar spine can reduce complications and risks in surgery for pedicle screw insertion. This study also provides information for spine instruments manufacturers (3). Studies have shown that the size of the lumbar vertebral pedicle varies in different populations (9–11). Pedicle is a gold standard safe method for spinal fusion that is widely used to treat many diseases such as trauma, infection, tumors and spinal instability, especially in the treatment of scoliosis. Studies have also shown that CT scan is the best way to measure lumbar vertebral pedicle (4). There are differences in the size of the pedicle based on gender and ethnicity, which need to be considered to avoid nerve damage during pedicle screw embedding (12). Due to the fact that different ethnic groups such as Fars-native ethnic group in Golestan province and so far, no study has been conducted about the role of ethnicity and gender in determining different dimensions of lumbar vertebrae in this region and considering the importance of determining measurement of height, width, and length of right and left lumbar vertebrae by CT scan in three axial, coronal and sagittal views, the present study was conducted to compare the dimensions of right and left lumbar

vertebrae between male and female people of Fars-native ethnic group in this region.

## Methods

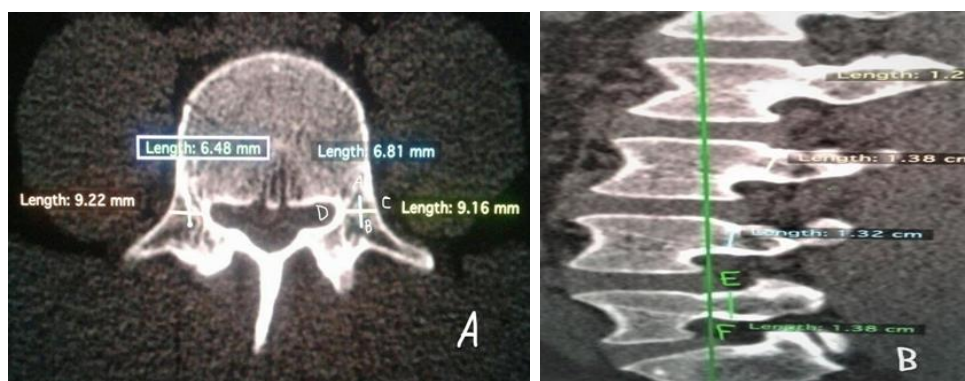
This cross-sectional study was approved by the Ethics Committee of Golestan University of Medical Sciences under code IR.GOUMS.REC.1397.158 among 40 people of Fars-native ethnic group (20 males and 20 females) in the age range of 18 – 45 years and average height of 165 to 180 cm for men and 165 to 175 cm for women, and was performed in Panjom Azar Hospital in 2018.

Written informed consent was obtained from the study participants. After obtaining written consent, CT Scan was performed for all subjects. Subjects were coded in this study and were identified and analyzed only with the relevant code, and the names of the subjects and any information contained in the CT Scan remained confidential.

CT Scan was not performed on asymptomatic subjects and unnecessary cases. Patients undergoing lumbar vertebra CT Scan with signs of low back pain, tumor, listhesis, infection, lysis, and trauma were included in the study. Evaluations were also performed on healthy vertebrae. The vertebrae that had fractures, infections, spondylosis (spinal arthritis), tumors, etc. for any reason, which changed the shape of the vertebra, were excluded from the study.

Measurements of lumbar vertebral pedicle dimensions including length, width and height based on three axial, coronal and sagittal views in 1.5 mm sections was done by the Siemens SOMATOM Emotion 16 CT scanner using Osirix application Ver. Osirix MD. Pedicle length was considered as AB line from body at anterior margin of vertebral foramen to lamina (Fig. 1A) and transverse process of lumbar vertebra and pedicle width at isthmus area as DC line in axial view (Fig. 1B) and pedicle height as green FE line (Fig. 1B) based on the sagittal view.

The results were analyzed by Chi-square test for qualitative variables and independent T-test for quantitative variables. Statistical analysis was performed using SPSS version 18 and  $p < 0.05$  was considered significant.



**Figure 1.** Figure B shows the pedicle height (EF), and Figure A shows the length (AB) and width (DC) of the lumbar vertebral pedicle.

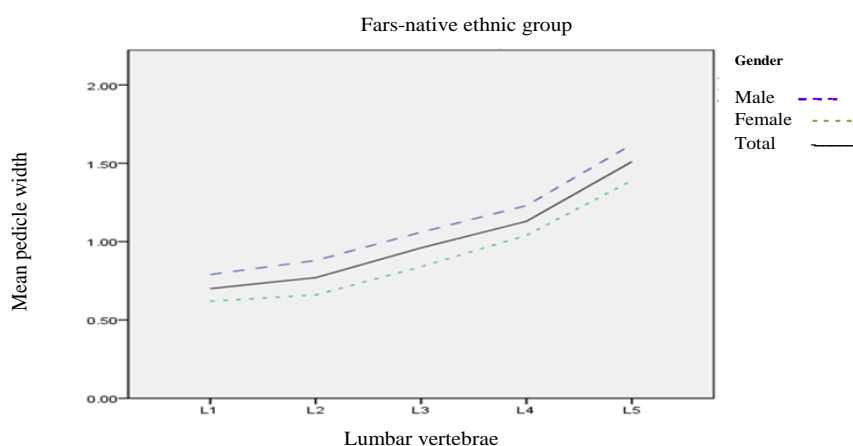
## Results

The present study showed that the mean and standard deviation of height ( $1.458 \pm 0.141$ ), width ( $0.788 \pm 0.173$ ), and length ( $1.248 \pm 0.195$ ) of pedicle in men (based on millimeter) was significantly higher compared to mean and standard deviation of height ( $1.268 \pm 0.140$ ), width ( $0.618 \pm 0.148$ ), and length ( $1.08 \pm 0.174$ ) of pedicle in women ( $p < 0.05$ ). The widest average width of pedicle was in the L5 vertebra between the vertebrae L1 – L5. The average width of the left L5 pedicle was 16.41 mm in men and 14.20 mm in women ( $p = 0.001$ ). The narrowest average width of pedicle was in L1 between the vertebrae L1 – L5.

The size of the right pedicle was 7.88 mm in men and 6.18 mm in women ( $p = 0.002$ ). In the L1 vertebra, the size of the left pedicle was 7.79 mm in men and 6.34 mm in women ( $p = 0.004$ ). The widths of the right pedicle of men in the L2, L3, and L4 vertebrae were 8.75, 10.58 and 12.21 mm, respectively, and in the left pedicle of men were 8.75, 10.63 and 12.50 mm, respectively. The mean widths of the right pedicle in women in the L2, L3, and L4 vertebrae were 6.57, 8.75, and 10.26 mm, respectively, and in the left pedicle were 6.70, 8.69, and 10.61 mm, respectively. The transverse

pedicle isthmus width is shown as DC line in Fig. 1A. This study showed that the average width of right and left pedicle in men and women increased from L1 to L5 and there was a significant difference in the width of pedicle between men and women (Fig 2) ( $p < 0.05$ ), and this difference in size was higher in men compared to women. According to Table 1, the length of the pedicle in Fig. A from the posterior part of the body to the anterior margin of vertebral foramen to lamina and transverse process is shown as AB line in Fig. 1, which is the location of the pedicle screw. The height of the pedicle in Figure 1B is shown as the EF line, which shows the thickness.

The study also showed that there was no significant difference between men and women in the length of the right pedicle in L4 and L5 vertebrae and the length of the left pedicle in L3, L4 and L5 vertebrae (Table 1) and the length of the pedicle showed a decreasing trend (Fig 3). The present study showed that the height of the lumbar vertebrae in the right and left pedicles decreased in men and women from L1 to L5 (Table 1 and Fig 4), and the lines showed decreasing trend similar to the length of the pedicle, unlike the width of pedicle, which had an increasing trend.



**Figure 2.** The width of lumbar vertebral pedicle (mm) in men and women in Fars-native ethnic group

Table 1. Dimensions of right and left lumbar vertebral pedicle based on gender

Variables		Mean±SD		P-value
		Male (n=20)	Female (n=20)	
Dimensions of right lumbar vertebral pedicle (mm)	Height of L1 vertebra	1.41±14.58	12.68±1.40	* 0.001
	Width of L1 vertebra	7.88±1.73	6.18±1.48	* 0.002
	Length of L1 vertebra	12.43±1.95	10.80±1.74	* 0.008
	Height of L2 vertebra	13.51±1.22	12.21±1.40	* 0.004
	Width of L2 vertebra	8.75±1.54	6.57±1.03	* 0.001
	Length of L2 vertebra	11.03±2.18	9.49±1.50	* 0.013
	Height of L3 vertebra	13.6±1.54	12.45±1.4	* 0.016
	Width of L3 vertebra	10.58±1.84	8.75±1.33	* 0.001
	Length of L3 vertebra	9.71±1.98	8.36±1.58	* 0.023
	Height of L4 vertebra	12.97±1.36	11.65±1.48	* 0.006
	Width of L4 vertebra	12.21±1.75	10.26±1.52	* 0.001
	Length of L4 vertebra	8.28±1.50	7.45±1.45	0.082
	Height of L5 vertebra	12.22±1.51	10.79±1.38	* 0.003
	Width of L5 vertebra	16.14±1.94	13.68±2.03	* 0.001
	Length of L5 vertebra	6.61±1.20	6.29±1.01	0.376
Dimensions of left lumbar vertebral pedicle (mm)	Height of L1 vertebra	14.58±1.41	12.70±1.39	* 0.001
	Width of L1 vertebra	7.98±1.88	6.34±1.46	* 0.004
	Length of L1 vertebra	12.19±1.80	10.98±1.43	* 0.024
	Height of L2 vertebra	13.89±1.25	12.28±1.30	* 0.001
	Width of L2 vertebra	8.92±1.44	6.70±1.02	* 0.001
	Length of L2 vertebra	11.11±1.97	10.04±1.07	* 0.04
	Height of L3 vertebra	13.55±1.43	12.10±1.37	* 0.002
	Width of L3 vertebra	10.63±1.67	8.69±1.37	* 0.001
	Length of L3 vertebra	9.80±1.91	8.91±1.24	0.09
	Height of L4 vertebra	12.88±1.48	11.72±1.17	* 0.009
	Width of L4 vertebra	12.50±1.99	10.61±1.60	* 0.002
	Length of L4 vertebra	8.20±1.59	7.74±1.41	0.346
	Height of L5 vertebra	11.95±1.65	10.95±1.18	* 0.033
	Width of L5 vertebra	16.41±1.65	14.20±2.29	* 0.001
	Length of L5 vertebra	6.78±1.19	6.31±0.93	0.174

\* Indicates a significant difference in the dimensions of the right and left pedicle according to gender in Fars-native ethnic group ( $p < 0.05$ ).

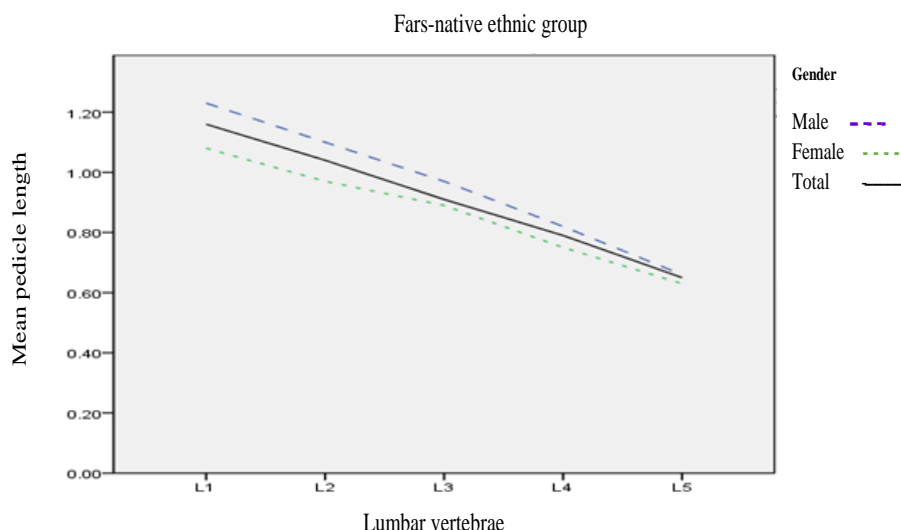
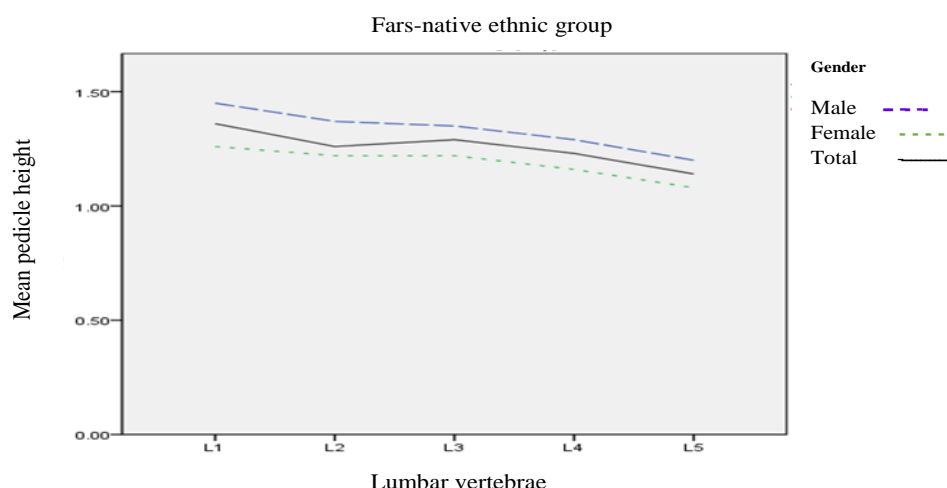


Figure 3. The length of lumbar vertebral pedicle (mm) in men and women in Fars-native ethnic group



**Figure 4. The height of lumbar vertebral pedicle (mm) in men and women in Fars-native ethnic group**

## Discussion

In the present study, there was a significant difference in the size of the lumbar vertebra pedicle between men and women. This size was greater in men than in women. The present study also showed that pedicle width increased from L1 to L5 vertebrae in men and women. The pedicle width increased from L1 to L5 vertebrae, however, the length and height of the pedicle showed a decreasing trend from L1 to L5 vertebrae. The findings of this study are consistent with those of Lotfinia et al., Gulec et al., Alam et al., and Nojiri et al. (3, 4, 13, 14).

In the study of Gulec et al. in Turkey, the height, width and length of the L1 to L5 vertebrae were evaluated in both men and women. In this study, the dimensions of the pedicle varied with age, yet no difference was observed in terms of gender or height (3). Comparison of the Turkish population with the population of the study of Lotfinia in Tabriz showed that the length of the pedicle except for the L2 vertebra, which increased slightly, decreased from L1 to L5 vertebrae (4). Furthermore, the length and height of pedicle were significantly higher in Turkish subjects than in our study and showed increase in pedicle widths, except for minor amounts in men in L2 and L3 vertebrae (3). In our study, the length and width of lumbar vertebral pedicle were smaller than the population of Lotfinia et al. (4) in Tabriz. In this study, the width of the pedicle increased from L1 to L5, and the length of the pedicle decreased except in L2.

There was a significant difference in the size of the lumbar vertebral pedicle between men and women in Tabriz (5). This was greater in men than in women. A study by Gosal et al. in the Indian population using CT

scan and digital orthopedic software on the width and length of pedicle of thoracic and lumbar vertebrae showed that the median width of pedicle increased from D9 to L5 (15). Alam et al. in Pakistan showed that the width of the pedicle increased from L1 to L5 and the pedicle height decreased (13).

These variables were higher in men than in women. There was a statistically significant difference for the transverse and anterior-posterior diameters of the vertebral body and the sagittal diameter of the pedicles on the left side. Population comparison showed a statistically significant difference in height and width of pedicle between Pakistani population and other people. In a study by Chawla et al. in the northwest of India, consistent with our study, pedicle width increased in men and women from L1 to L5 (16). Tall et al. performed a morphometric analysis on pedicle in the African population, and found results consistent with the present study (17).

A study by Mughir et al. in the Malaysian population of youth and adolescents on pedicle length and width revealed that pedicle length and width were greater in youth than adolescents (18). The present study, consistent with studies in different countries (4, 13, 14), showed that the size of different dimensions of pedicle varies in different populations. The present study in Gorgan was aimed at understanding the morphometry of lumbar vertebral pedicle to help surgeons reduce the neurological complications during pedicle screw implantation and to provide information to spine instruments manufacturers and to help understand the movements of the lumbar spine.

The obtained results showed a significant difference in the size of the pedicle between men and women, the

effect of gender on the size of the lumbar pedicle, and the size of the lumbar pedicle in different populations. Differences observed in different studies can be due to genetic, ethnic, or geographical and nutritional factors. Further studies relying on the aforementioned factors are needed to determine these differences.

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